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PREPARATION OF SOIL ANALYSIS FOR CONSTRUCTION OF COMMERCIAL COMPLEX: A MODEL STUDY

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ABSTRACT

Soil sampling and testing is one of the most important steps to attain success in construction projects. Soil testing provides information on type of soil, Bearing capacity of soil etc., An unprecedented amount of construction projects has been delay or even being cancelled because of soil unsuitability. Soil samples have been collected from the proposed site to check suitability for the construction of commercial complex. Tests such as Field dry density, Natural moisture content , particle size analysis, soil fraction retained on 4.75mm ISS, Soil fraction passing 4.75mm ISS, Atterbergs limits, Specific gravity, Shear test, Direct shear test, Consolidation test and Differential free swell test are done for testing the suitability and stability of soil for the construction of commercial complex.

Key words: soil, Construction, testing.

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1. INTRODUCTION

Soil testing plays an integral role and is a pre-requisite for construction. The strength of the building will depend to a large extent on the soil. There are certain limits to construction depending on the kind of soil. This soil testing will be used to Determine the suitability of the soil and assess whether it can accommodate construction project, To Identify the different types of soil on site and their location, Test soil for strength, density, compaction, contamination, organics and sand content, and assess their impact on construction project, Gain the data needed to compile technical and safety data reports to support planning permissions and license applications and to Get precise results and observe the development of the soil throughout the construction project for maximum quality and safety.

2. DESCRIPTION OF STUDY AREA

The proposed complex has been developed in an area of 27.082 acres. The project will comprise of six buildings and total construction area is 58655.43 sq.mt. In addition about 18.047 acres of adjoining site will be developed for public facilities. Site plan provided for 45.129 acres. K C Canal Railway Station near Tadepalli at 14km in NE direction. Gannavaram Airport, 35km in the East direction. Site is located 30km apart from Guntur. This project site is fairly plain land with minimum undulations. A 0.9 m rise from road level is planned. Additional filling material of about 27000 cu mts is required with a combination of 30 % Fly ash, 40 % Quarry dust, 30 % Gravel. The climate of proposed site is tropical in nature with hot summers and moderate winters. The months of April to June are the summer months with the temperature ranging from a minimum of 27^0 C to 45^0 C. The temperature during winter months ranges from 28^0 C to 17^0 C. The average humidity ranges from 68% to 80% during summer season. The annual rainfall in the region is about 965mm and is contributed by the south west monsoons.

3. METHODOLOGY

Soil samples obtained in their disturbed and undisturbed types from trial pits were subjected to various laboratory investigations such as (a) Indices tests, which include natural moisture content, specific gravity, liquid limit, plastic limit and unit weight, (b) Physical experimentation like sieve analysis for establishing the particle size distribution curves and for soil classification and (c) Free swell index tests on clayey soils, especially, to know the degree of expansiveness of these soils. In addition, strength tests such as Unconfined compressive strength and Direct shear tests, based on the soil type, have also been conducted on Un Disturbed Soil Samples to determine the shear strength parameters i.e., cohesion, C, and angle of internal friction, ϕ, of the soils. Results obtained are presented in Table 1a Construction of Commercial Complex near Guntur, Andhra Pradesh.

3.1. Field Dry Density & Natural Moisture Content

The weight of undistributed soil sample with sampler (Shelby tube) is determined after removing paraffin wax and loose soil. The total length of soil sample recovery is determined after deducting empty length from the total length of sampler. The volume of soil mass retained in sampler is thus determined from the known inside diameter of sampler and total length of soil mass. The soil mass is then removed and the average moisture content is determined by keeping the soil sample along with crucible in oven at 100-105 degree centigrade for 24 hours. The empty weight of the sampler is then found out. From the total weight of sampler with soil mass, the weight of empty sampler is deducted. The field density is then found out as follows.

$$\text{Field density} = \frac{\text{Weight of the soil mass}}{\text{Volume of soil mass}}$$

3.2. Particle Size Analysis

The sieve analysis is carried out in accordance with IS: 2720 (Part 4, 1985). The results are presented in the form of Grain size distribution curve.

Representative soil sample is obtained from the bulk soil sample collected or received from site by method of coning and quartering. Quantity of soil taken will be dependent on the maximum size of particle size present in the soil. Sieve analysis is conducted in two parts.

3.3. Soil Fraction Retained on 4.75 mm ISS

Soil portion retained on 4.75 ISS is weighed. The sample is then separated into various fractions by Sieving through the following sieves: 100, 75, 19 and 4.75 mm ISS. While sieving through each sieve, sieve is agitated so that sample rolls in irregular motion over the sieve, at no time the particles are pushed through; Care is also taken to see that no individual soil particles are broken, though particles adhering one another are rubbed by rubber pestle when required. Care is also taken not to over load the sieve beyond the permitted maximum load for respective sieve. The mass of the material retained on each sieve is recorded The percentage of soil retained on each sieve is then calculated on the basis of the total mass of soil taken and from these results, the percentage passing through each sieve is calculated.

3.4. Soil Fraction Passing 4.75 ISS

The portion of the soil passing 4.75mm ISS is oven dried at 105 to 110 centigrade. The portion is coned & quartered to obtain required representative quantity of the material. The material is weighed and placed in tray/bucket filled with water for soaking and loosening the adhered cohesive materials. The soaked soil specimen is then washed on 75 micron IS Sieve until the water passing the sieve is almost clear. The material retained on 75 micron IS Sieve is then transferred in a tray, dried in oven. Sieve analysis is then conducted on a nest of sieves (viz. 2 mm, 425 and 75 micron ISS) either by hand or by using mechanical sieve shaker. The fraction retained on each of the sieves is weighed separately and masses recorded. Cumulative mass of soil fraction retained on each sieve is then calculated. The combined gradation on the basis of the total sample taken for analysis is finally calculated.

3.5. Atterberg's Limits

For fine grained soils, consistency limits are important in addition to natural moisture content. The Consistency Limits are Liquid Limit, Plastic Limit and Shrinkage Limit. Liquid and plastic limits are determined by using procedure given in IS: 2720.The Liquid Limit test was conducted on disturbed soil samples using Cassagrande's Liquid Limit device and grooving tool. The moisture content of the soil paste corresponding to number of blows required to close the grove made by the grooving tool in the apparatus is determined. The liquid limit of the soil which corresponds to the moisture content of a paste which would give 25 blows is determined from the flow curve. For determination of plastic limit, a soil sample weighing at least 20 gm from the soil sample passing 425micron IS sieve is thoroughly mixed with water such that it can be easily moulded with fingers. A ball is formed with about 8 to 10 gm of this soil and is rolled between the fingers and the glass plate with just sufficient pressure to roll the mass into a thread of uniform diameter of 3mm throughout its length. The soil is then kneaded together to a uniform mass and rolled again. The process is continued until the

thread crumbles. The pieces of crumbled soil thread are collected and moisture content is determined and reported as plastic limit.

3.6. Specific Gravity

The specific gravity of soil solids is determined by a 50ml density bottle. The weight (Wl) of the empty dry bottle is taken first. A sample of oven-dried soil about 10-20 g cooled in a desiccator, is put in the bottle, and weight (W2) of the bottle and the soil is taken. The bottle is then filled with distilled water gradually removing the entrapped air either by applying vacuum or by shaking the bottle. The weight(W3) of the bottle, soil and water (full up to the top) is then taken. Finally the bottle is emptied completely and thoroughly washed and clean water is filled to the top and the weight (W4) is taken.

$$\text{Specific gravity (G)} = \frac{(W2-W1)}{(W2-W1) - (W2-W4)}$$

3.7. Shear Test

Tri-axial (un drained) tests are carried out to determine the shear parameters. The shear tests are carried out in accordance with IS: 2720 on saturated samples. For unconsolidated un drained tri-axial compression test, the undisturbed soil specimen having diameter 38 mm and height to diameter ration 2 is prepared and placed on the pedestal of the tri-axial cell. The cell is then assembled with the loading ram and then placed in the loading machine. The cell fluid is admitted to the cell and the pressure is raised to the desired value. An initial reading of the gauge measuring axial compression of the specimen is recorded. The test is then commenced and sufficient number of simultaneous readings of load and compression measuring gauge being taken. The test is continued until the maximum value of the stress has been passed or until an axial strain of 20 per cent has been reached. Additional tests are carried out on identical specimen at Confining pressure of 1kg/cm^2, 2 kg/cm^2 and 3 kg/cm^2. The shear parameters are obtained from the plot of Mohr circles.

3.8. Direct Shear Test

Direct Shear Test is carried out using shear box with the specimens (60mm x 60mm). Specimen with plain grid plate at the bottom of the specimen and at the top of the specimen is fitted into position in the shear box housing and assembly placed on the load frame. The serrations of the grid plates are kept at right angle to the direction of shear. The loading pad is kept on the top grid plate. The required normal stress is applied and the rate of longitudinal - displacement/shear stress application so adjusted that no drainage can occur in the sample during the test (1.25mm/min). The upper part of the shear box is raised such that a gap of about 1mm is left between the two parts of the box. The test is conducted by applying horizontal shear load to failure or to 20 percent longitudinal displacement whichever occurs first. The test is repeated on identical specimens.

3.9. Consolidation Test

The consolidation tests were carried out on undisturbed soil specimen in order to determine the settlement characteristics of soil at different depths. The tests were conducted in accordance to IS: 2720.

An undisturbed soil specimen is extruded to the consolidation ring of 60mm diameter. The edge is trimmed carefully such that the sample flushes with the top and bottom edges of the ring. The thickness of the specimens measured and the weight is recorded. The bottom porous stone is then centered on the base of the consolidation cell.

The specimen is placed centrally between the bottom porous stone and the upper porous stone. A filter paper is provided in-between specimen and porous stones. Then the loading cap is placed on the top. The consolidometer is placed in position with the loading device and suitably adjusted. The dial gauge is then clamped into position for recording the relative movement between the base of the cell and the loading cap. A seating pressure of 0.05 kg/cm2 is applied to the specimen. The cell is kept filled with water. After 24 hours the test is continued using a loading sequence on the soil specimen of 0.25, 0.5, 1.0, 2.0, 4.0 and 8.0 kg/cm^2. For each loading increment after application of load, readings of the dial gauge is taken using time sequence 0, 0.25, 1, 2.25,2,.6.25,9,16,25,36,49 up to 24 hrs. From the observations of all incremental pressure, void ratio versus log (pressure) curve is obtained. The slope of the straight line portion is designated as compression index Cc.

3.10. Differential Free Swell Test

In order to determine the swelling characteristics of the soil, differential free swell test is carried out on oven dried soil sample. 10 gm passing through 425 micron is poured in two 100 ml graduated cylinders. One cylinder was filled with distilled water and another with kerosene up to 100 ml mark. After removal of entrapped air, sample was allowed sufficient time to attain equilibrium state of volume. The final volume of soil in each cylinder was recorded.

$$\text{DFS} = \frac{\text{Soil volume in water} - \text{Soil volume in kerosene}}{\text{Soil volume in kerosene}}$$

4. RESULTS AND DISCUSSION

Natural moisture content value is recorded as 26.15% for MH-CH type of soil of depth 22-22.45 m and It is 20.65 for same MH-CH soil but at a depth of 2 to 2.45m , it is 21.35% for same MH-CH type of soil at a depth of 4-4.45m, it is recorded as 22.25% for the same MH-CH type of soil at a depth of 6 to 6.45m , It is recorded as 14.70% least for same MH-CH soil of depth 8-8.45 m. Natural moisture content for MI-CL type of soil is recorded as 16.80% at a depth of 10to 10.45m and it is recorded 19.55% at a depth of 16 to 16.45m and it is 20.50% and 25.50% at a depths 18 to 18.45 and 20 to 20.45 respectively. Whereas for SM-SC soil Natural moisture content is 17.90% and 18.49% at a depths of 12 to 12.45% and 14 to 14.45% respectively. Bulk unit weight (γ_d) is recorded highest as 17.50 KN/m^3 for MH-CH soil of depth 22-22.45 m and it is recorded lowest for same MH-CH soil as 12.16 KN/m^3 at a depth 2 to 2.45m.It is recorded as 3.90KN/m^3, 14.50KN/m^3, 14.75KN/m^3 for same MH-CH type of soil for depths 4 to 4.45m, 6 to 6.45m and 8 to 8.45m respectively. Bulk unit weight for MI-CL type of soil is recorded as 15.25KN/m^3, 16.85KN/m^3, 16.95KN/m3, 16.75KN/m^3 at depths of 10 to 10.45m, 16 to 16.45m, 18 to 18.45m and 20 to 20.45m respectively and for SM-SC type of soil Bulk unit weight is recorded as 16.10KN/m^3,16.50KN/m^3 at depths of 12 to 12.45m and 14 to 14.45m respectively. Unconfined compressive strength is recorded as 10KN/m^2 as a highest value for MI-CL and SM-SC type of soils at a depths of 10 to 10.45m and 14 to14.45m respectively and for MH-CH type of soil of depths 2 to 2.45m and 6 to 6.45m it is recorded as 0KN/m^2 and also for MI-CL type of soil of depth 18 to 18.45 is recorded 0KN/m^2. Safe bearing capacity is recorded as 380.80KN/m^2 highest for SM-SC type of soil up to a depth of 14 to 14.45m and it is recorded as 325.50 KN/m^2 for the same type of soil at a depth of 12 to 12.45m.For MH-CH type of soil , Safe bearing capacity values are recorded as 112.50KN/m^2, 149.29KN/m^2,175.40KN/m^2,205.25KN/m^2 and 165.50KN/m^2 at depths of 2-2.45m,4-4.45m,6-6.45m,8-8.45m and 22 to 22.45m respectively.

Table 1 Soil Sample Analysis

<table>
<tr><th rowspan="2">Sample details</th><th rowspan="2">Sample type</th><th rowspan="2">Sample depth (m)</th><th rowspan="2">IS Soil Classification</th><th rowspan="2">NMC (%)</th><th rowspan="2">γ_d (kN/m^3)</th><th rowspan="2" colspan="2">Recorded N value</th><th rowspan="2" colspan="2">Corrected N value</th><th rowspan="2">S_u (kN/m^2)</th><th colspan="2">DST</th><th rowspan="2">SBC (kN/m^2)</th></tr>
<tr><th>C (kN/m^2)</th><th>ϕ (deg)</th></tr>
<tr><td>UDS</td><td>UDS</td><td>2-2.45</td><td>MH-CH</td><td>20.65</td><td>12.16</td><td>-</td><td>-</td><td>86</td><td>43</td><td>0</td><td colspan="3">112.50</td></tr>
<tr><td>UDS</td><td>SPT</td><td>4-4.45</td><td>MH-CH</td><td>21.35</td><td>13.09</td><td>20</td><td>22</td><td>-</td><td>-</td><td>-</td><td colspan="3">149.29</td></tr>
<tr><td>UDS</td><td>UDS</td><td>6-6.45</td><td>MH-CH</td><td>22.25</td><td>14.50</td><td>-</td><td>-</td><td>170</td><td>85</td><td>0</td><td colspan="3">175.40</td></tr>
<tr><td>UDS</td><td>SPT</td><td>8-8.45</td><td>MH-CH</td><td>14.70</td><td>14.75</td><td>24</td><td>20</td><td>-</td><td>-</td><td>-</td><td colspan="3">205.25</td></tr>
<tr><td>UDS</td><td>UDS</td><td>10-10.45</td><td>MI-CL</td><td>16.80</td><td>15.25</td><td>-</td><td>-</td><td>224</td><td>112</td><td>10</td><td colspan="3">271.50</td></tr>
<tr><td>UDS</td><td>SPT</td><td>12-12.45</td><td>SM-SC</td><td>17.90</td><td>16.10</td><td>30</td><td>25</td><td>-</td><td>-</td><td>-</td><td colspan="3">325.50</td></tr>
<tr><td>UDS</td><td>UDS</td><td>14-14.45</td><td>SM-SC</td><td>18.49</td><td>16.50</td><td>-</td><td>-</td><td>250</td><td>125</td><td>10</td><td colspan="3">380.80</td></tr>
<tr><td>UDS</td><td>SPT</td><td>16-16.45</td><td>MI-CL</td><td>19.55</td><td>16.85</td><td>21</td><td>18</td><td>-</td><td>-</td><td>-</td><td colspan="3">327.50</td></tr>
<tr><td>UDS</td><td>UDS</td><td>18-18.45</td><td>MI-CL</td><td>20.50</td><td>16.95</td><td>-</td><td>-</td><td>298</td><td>146</td><td>0</td><td colspan="3">338.15</td></tr>
<tr><td>UDS</td><td>SPT</td><td>20-20.45</td><td>MI-CL</td><td>25.50</td><td>16.75</td><td>23</td><td>19</td><td>-</td><td>-</td><td>-</td><td colspan="3">305.5</td></tr>
<tr><td>UDS</td><td>SPT</td><td>22-22.45</td><td>MH-CH</td><td>26.15</td><td>17.50</td><td>11</td><td>8</td><td>-</td><td>-</td><td>-</td><td colspan="3">165.50</td></tr>
<tr><td colspan="14">IS: Indian Standard; NMC: natural moisture content; γ_d: bulk unit weight; S_u: Unconfined compressive strength; C: cohesion; ϕ: angle of internal friction; DST: Direct shear test; SBC: safe bearing capacity; DS: disturbed sample; UDS: undisturbed sample;</td></tr>
</table>

Figure 1

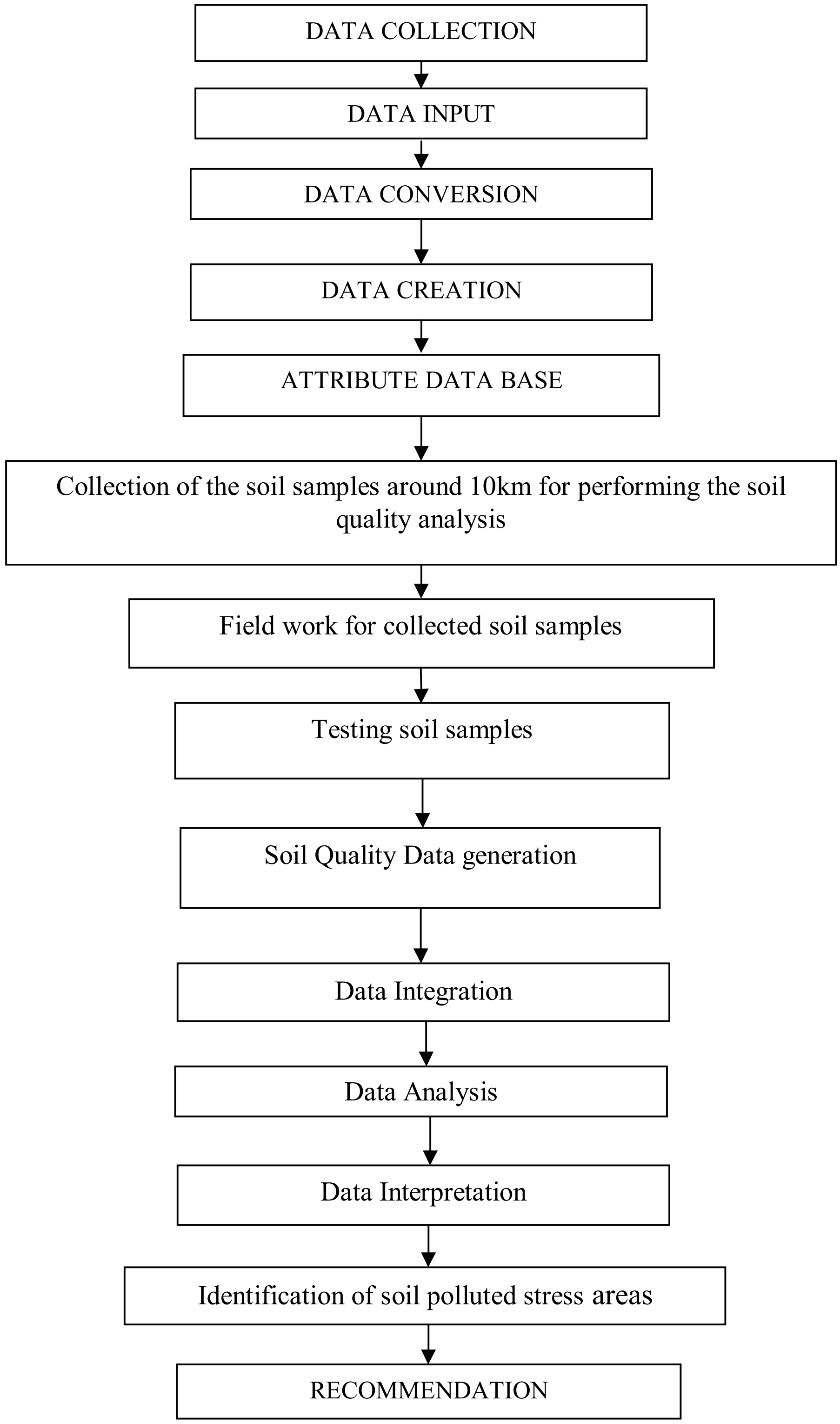

Figure 2 Flow chart adopted for the present study

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